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ABSTRACT

INTRODUCTION: Electronic cigarettes (e-cigarettes) have grown in popularity, especially among youth and young adults. Although e-cigarettes were originally intended to vaporize a liquid mixture containing nicotine, there appears to be an increasing trend in other substance use in e-cigarettes (OSUE).

MATERIALS AND METHODS: Cross-sectional data from 1542 undergraduate college student e-cigarette users from a large Midwestern university were collected via online survey to assess prevalence of e-cigarette use, reasons for use, perceived harm, and prevalence and predictors of OSUE.

RESULTS: Nearly 7% (6.94%) reported using an e-cigarette to vaporize and inhale a substance other than nicotine. Current tobacco cigarette smokers were significantly more likely to report OSUE (51.0%) as compared with never (33.7%) and former (15.4%) smokers. Among respondents reporting OSUE, the primary reason for e-cigarette use was "safer than cigarettes" (21.7%), followed by "experimentation" (18.9%) and "friends use" (17.0%). Most (77.9%) reported using cannabis or some derivative of cannabis in an e-cigarette. Binomial logistic regression found that women were less likely to report OSUE by a factor of 0.60, former tobacco cigarette smokers as compared with never smokers were more likely to report OSUE by a factor of 1.87, and e-cigarette users who reported using e-cigarettes for "cool or trendy" reasons were more likely to report OSUE by a factor of 2.89.

DISCUSSION: Little is known regarding the health effects of cannabis and cannabis derivatives delivered through e-cigarettes. Concern may also be warranted regarding the potential dangers of this young population using substances more dangerous than cannabis in e-cigarettes. Knowledge is limited regarding the public health impact of vaping cannabis or other illicit substances among college student populations. This study stresses the need for continued research regarding the vaping of cannabis and other illicit substances among college students.

KEYWORDS: Electronic cigarettes, college students, other substance use, young adults, smoking, vaping

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Introduction

Electronic cigarettes (e-cigarettes) deliver nicotine, flavor, and other chemicals by heating these substances into aerosols that can be inhaled by the consumer.[1] (Electronic-cigarette [e-cigarette] refers to all popular devices used to vaporize substances [eg, mods, advanced personal vaporizers, vape pens].) Since entering the US market in 2007, e-cigarettes have swiftly risen in popularity. Past 30-day use of e-cigarettes among college students has risen from 1.5% in 2009 to 14.0% in 2014.[2] Studies have shown that the prevalence of e-cigarette use is higher among younger populations, particularly in men.[3] It has been found that 4.9% of college students have used e-cigarettes, with 12% of those users never trying traditional cigarettes.[4] Another more recent study found that 27.9% of college students reported ever using an e-cigarette, with 13.9% of those individuals reporting never being regular tobacco cigarette users.[5]

Although e-cigarettes were originally intended to vaporize a liquid mixture typically containing nicotine, glycerin/propylene glycol, and flavoring, commonly referred to as "e-liquid" or "e-juice," other substance use in e-cigarettes (OSUE; eg, cannabis, supplements, cocaine) has become increasingly popular among some e-cigarette users as noted by recent studies.[6,7] Morean et al[8] reported that among high school students, 5.4% reported vaporizing cannabis using an e-cigarette. However, most of what we know about this emergent trend comes from a relatively small number of published studies[6–11] and media reports[12,13] and is likely underreported overall. Web sites and forums such as Erowid, Bluelight, and Drugs-Forum include communication

regarding experiences using e-cigarettes and other devices to vaporize substances other than nicotine. These communications include discussions regarding the feasibility of vaporizing substances other than nicotine and instructions on how to effectively vaporize such substances. The Internet is also rich with YouTube videos of individuals demonstrating how to use e-cigarettes and other vaporizer devices to vaporize substances such as "wax" (concentrated tetrahydrocannabinol [THC]) or other substances. Likely responding to consumer demand and closely mirroring the approach of manufacturers of cannabis paraphernalia, some manufacturers of e-cigarettes and other similar devices increasingly offer accessories or attachments for e-cigarettes that are specifically designed for effectively and more efficiently vaporizing various other substances.[14]

Among college-aged adults, the perception of e-cigarettes is generally favorable and many of these young individuals are willing to experiment with e-cigarettes. This favorable perception and willingness to experiment is linked to beliefs that e-cigarettes are less harmful than traditional cigarettes.[15–18] Furthermore, studies have found that individuals also perceive the use of substances such as cannabis to be safer when vaporized versus combusted.[19,20]

Although there have been a growing number of recent studies regarding the vaping of other substances in e-cigarettes, few have focused on the young adult college student. College students are a potentially vulnerable population about which there is little published data regarding the use of other substances in e-cigarettes. It is important to learn more about the prevalence of the behavior, types of substances being vaporized, and the characteristics of individuals engaging in the behavior, especially among college student populations, where daily cannabis use and past year cocaine use[21] and prescription drug misuse[22] are increasing. Given the increased freedoms that generally accompany college students (eg, less parental supervision), the general perception that vaporization of substances is less harmful than traditional combustible methods of ingestion,[4,19,20] and the discreteness that e-cigarettes provide when vaping substances other than nicotine,[11] it is reasonable to believe that the use of e-cigarettes to vaporize substances other than nicotine could increase, resulting in an increased risk of substance use disorders among this young population.

To better understand the use of e-cigarettes among college students to vaporize and inhale other substances, this study sought to assess the prevalence of e-cigarette use, perceived harm and reasons for e-cigarette use, prevalence and types of other substances used in e-cigarettes, past 30-day drug use, and predictors of OSUE in a cross-sectional sample of students at a large Midwestern university.

Methods

Sample

A cross-sectional, online survey was distributed via email to all students enrolled at a large Midwestern university (n = 35 299) and 9494 responded (26.9% response rate). The survey was available for 8 days beginning January, 2014. Students received an email containing an invitation to complete the survey, which indicated that the student had been selected to complete an anonymous survey regarding e-cigarettes. The email also indicated that the survey would take approximately 10 to 15 minutes to complete and that participation in the survey qualified the respondent for a prize drawing that included 20 gift cards of varying denominations ranging from $15 to $50 each. A link was provided in the email that took respondents to the survey.

On completion of the survey, respondents wishing to enter the prize drawing were provided a link to a separate online form that requested respondent name and contact information. Reminders were sent via email to all individuals who had not tried to access or had not yet completed the survey. Reminders to complete the survey were emailed on the fourth and seventh day after the initial email invitation to complete the survey. The survey included skip patterns and was designed to prevent respondents from participating more than once or from forwarding the survey to others. This study includes only undergraduate students from the main university campus (N = 5429) who reported lifetime use of e-cigarettes (N = 1542). The study was approved by the university's Institutional Review Board.

Measures

Respondents were asked questions that included demographic characteristics, tobacco use (cigarette and smokeless), e-cigarette use and perceived harm of use, reasons for e-cigarette use, past 30-day drug use, and the use of other substances in e-cigarettes. Skip patterns were used so that questions not applicable to the respondent were not displayed.

Respondent demographic questions included age, sex, race/ethnicity, class rank, Greek affiliation, home residency status (eg, urban, rural, suburban), and international student status. Tobacco cigarette smoking status included current smoker, former smoker, or never smoker. Current or former smoker was defined as having smoked at least 100 cigarettes during the lifetime, and currently smokes every day or some days (current), or no longer smokes (former).[23] Questions regarding e-cigarette use included lifetime use ("Have you ever used an electronic cigarette?"), reasons for use, perceptions of harm (0 = very safe, 7 = very dangerous), and use of e-cigarettes to vape other substances ("Have you ever used or tried to use an e-cigarette to inhale another drug or substance other than nicotine?"). Past 30-day drug use was assessed by asking respondents to select from a list of drugs, each drug that had been used within the past 30 days. Participants who reported OSUE were presented with an open-ended question and asked to list each substance used in an e-cigarette.

Statistical analyses were conducted using SPSS version 22[24] and SAS 9.3.[25] Descriptive statistics were computed to examine demographic information for all e-cigarette users combined, e-cigarette users reporting OSUE, and e-cigarette users

Table 1. Respondent characteristics.

	TOTAL E-CIGARETTE USERS (N = 1542)	NO OSUE (N = 1236) 80.20%	OSUE (N = 107) 6.94%	χ^2 (*P* VALUE)
Age (mean/SD)	21.1 (4.0)	21.2 (4.1)	20.6 (2.8)	1.77 (.183)
Gender, No. %				8.22 (.004)
Male	686 (44.7)	523 (42.5)	61 (57.0)	
Female	850 (55.3)	707 (57.5)	46 (43.0)	
Race, No. %				3.38 (.184)
White	1366 (88.6)	1084 (87.7)	100 (93.5)	
Black	68 (4.4)	59 (4.8)	4 (3.7)	
Other	108 (7.0)	93 (7.5)	3 (2.8)	
Level of education, No. %				0.40 (.940)
Freshman	406 (26.3)	319 (25.8)	28 (26.2)	
Sophomore	358 (23.2)	288 (23.3)	23 (21.5)	
Junior	382 (24.8)	301 (24.4)	25 (23.4)	
Senior	396 (25.7)	328 (26.5)	31 (29.0)	
Greek affiliation, No. %				0.34 (.557)
Yes	201 (13.0)	160 (13.0)	16 (15.0)	
No	1340 (87.0)	1075 (87.0)	91 (85.1)	
Neighborhood, No. %				2.03 (.363)
Rural	394 (25.6)	324 (26.2)	22 (20.6)	
Urban	218 (14.1)	175 (14.2)	14 (13.1)	
Suburban	930 (60.3)	737 (59.6)	71 (66.4)	
International student, No. %				0.00 (.982)
Yes	19 (1.2)	17 (1.4)	0 (0.0)	
No	1522 (98.8)	1218 (98.6)	107 (100.0)	
Smoking status, No. %				8.51 (.014)
Never smoked	667 (45.3)	546 (46.3)	35 (33.7)	
Current smoker	556 (37.7)	432 (36.6)	53 (51.0)	
Former smoker	251 (17.0)	201 (17.1)	16 (15.4)	
Perceived harm (mean/SD)	3.3 (1.9)	3.4 (1.9)	3.0 (1.8)	3.20 (.074)

Abbreviation: OSUE, other substance use in e-cigarettes.
Some e-cigarette users (N = 199) did not respond regarding whether they used other substances in an e-cigarette.

not reporting OSUE. Covariates that were found to be significantly different (eg, $P < .05$) between OSUE and no OSUE groups, as determined by χ^2 analysis, were included in the binomial logistic regression to predict OSUE.

Results

Mean age of respondents was 21.1 years, 55.3% women, and 88.6% white (Table 1). Class rank was nearly evenly distributed across the 4 levels, with freshman making up 26.3% of the sample. Most respondents reported not being affiliated with a Greek organization (87.0%), and international students comprised 1.2% of the sample. Most of the sample reported growing up in a suburban neighborhood (60.3%). Most reported having never smoked tobacco cigarettes (45.3%), 37.7% reported being current tobacco smokers, and 17.0% were former smokers.

Table 2. Past 30-day substance use.

SUBSTANCE	OVERALL, NO. (%)	NO OSUE, NO. (%)	OSUE, NO. (%)	χ^2, *P* VALUE
Alcohol	1148 (85.0)	953 (84.0)	91 (95.8)	.002
Marijuana	550 (50.0)	421 (46.3)	73 (78.5)	<.000
Crack cocaine	—	—	—	—
Powdered cocaine	48 (21.0)	33 (19.5)	11 (28.2)	.232
Heroin	4 (14.3)	3 (13.6)	1 (20.0)	.718
Inhalants	6 (5.8)	6 (8.7)	—	.144
Methamphetamine	1 (2.6)	1 (3.2)	—	.684
Ecstasy	36 (13.7)	21 (11.0)	28 (66.7)	<.000
Hallucinogens	60 (18.4)	37 (15.1)	35 (67.3)	.003
Misused prescription pain medication	51 (13.0)	32 (10.5)	36 (72.0)	.001
Misused prescription stimulants	106 (21.5)	79 (20.6)	43 (69.4)	.077

Abbreviation: OSUE, other substance use in e-cigarettes.
Respondents could choose more than one drug used in past 30 days.

Table 3. Distribution of reasons for e-cigarette use among no OSUE and OSUE users.

NO OSUE (N = 1236), NO. (%)		OSUE (N = 107), NO. (%)	
Experimentation*	374 (31.6)	Safer than cigarettes	23 (21.7)
Friends use	254 (20.8)	Experimentation*	20 (18.9)
Safer than cigarettes	224 (18.3)	Friends use	18 (17.0)
Use under ban*	94 (7.7)	Trendy/cool*	15 (14.2)
Other	77 (6.3)	Other	13 (12.3)
Smoking cessation	75 (6.1)	Use under ban*	9 (8.5)
Trendy/cool*	64 (5.2)	Cheaper	3 (2.8)
Enjoy	44 (3.6)	Smoking cessation	2 (1.9)
Other tobacco cessation	10 (0.9)	Other tobacco cessation	2 (1.9)
Cheaper	8 (0.7)	Enjoy	1 (0.9)

Abbreviation: OSUE, other substance use in e-cigarettes.
Respondents in each category could choose more than one reason for e-cigarette use or could choose to not respond to the question.
*Significant at $P < .05$.

Nearly 7.0% of e-cigarette users reported OSUE. Although women comprised most of the overall e-cigarette–using sample, significantly more men (57.0%) than women (43.0%) reported OSUE. Reflecting the general student population of the university, respondents reporting OSUE were predominantly white (93.5%) and from suburban households (66.4%). Most respondents reporting OSUE were of senior class rank (29.0%) and Greek affiliation was reported by 15.0%. None of the respondents who reported being an international student also reported OSUE.

Current tobacco cigarette smokers were significantly more likely to report OSUE (51.0%) as compared with never (33.7%) and former (15.4%) smokers. Average perceived harm of using an e-cigarette was lower among respondents reporting OSUE but was not statistically significant.

Past 30-day substance use was indicated by more respondents reporting OSUE as compared with respondents not reporting OSUE (Table 2). This held for all substances, except inhalants and methamphetamine, where neither substance was reported by respondents reporting OSUE. Differences between the 2 groups of e-cigarette users in terms of past 30-day substance were significant for alcohol, cannabis, ecstasy, hallucinogens, and misused prescription pain medication.

As shown in Table 3, "experimentation" was the most reported reason for e-cigarette use among e-cigarette users

who did not report OSUE (31.6%), followed by "friends use" (20.8%) and "safer than cigarettes" (18.3%). Among e-cigarette users reporting OSUE, the most reported reason for e-cigarette use was "safer than cigarettes" (21.7%), followed by "experimentation" (18.9%) and "friends use" (17.0%).

Regarding the type of other substance use in an e-cigarette, most of the OSUE respondents reported the use of cannabis or some derivative of cannabis (77.9%) in an e-cigarette (Table 4). Hookah, herbs/supplements, and other substances were each reported by 1.9% of respondents. Seventeen (16.4%) respondents reported OSUE but refused to report or did not know what the other substance was.

Table 4. Types of other substance used in e-cigarette reported by OSUE users.

SUBSTANCE	NO. (%)
Marijuana or derivative (cannabis, weed, butane hash oil, hashish, dabs, wax, THC)	81 (77.9)
Unknown/not reported/would not share	17 (16.4)
Other illicit substances	2 (1.9)
Hookah	2 (1.9)
Herbs/supplements	2 (1.9)

Abbreviations: OSUE, other substance use in e-cigarettes; THC, tetrahydrocannabinol.

Results of the binomial logistic regression indicate that women were less likely to report OSUE as compared with men (odds ratio [OR]: 0.60, confidence interval [CI]: 0.39-0.91), and former smokers were more likely (OR: 1.87, CI: 1.16-3.04) to report OSUE than never smokers (Table 5). Electronic cigarette users using e-cigarettes for "trendy or cool" reasons were more likely (OR: 2.89, CI: 1.53-5.45) to report OSUE by a factor of nearly 3.

Discussion

This study sought to describe the characteristics of college students who use e-cigarettes to vape substances other than nicotine and to identify variables that predict OSUE, using a cross-sectional sample of college students at a large, Midwestern university. This study found that 6.94% of e-cigarette users reported OSUE. This rate is slightly higher than reports of OSUE in studies surveying high school students (5.4%)[8] but much lower than reports of OSUE in the only other known published study of OSUE among college students (29.0%).[11] The slightly higher rate found in this study as compared with prevalence rates reported among high school students is likely due to differences in the way the question was asked. For instance, this study asked respondents to report the prevalence of *any substance other than nicotine* in an e-cigarette, whereas Morean et al[8] asked respondents to report specifically on the use of cannabis in an e-cigarette. Variation in state laws where data were collected may have also affected reported prevalence rates. For example, Jones et al[11] collected data in a state where cannabis is legal for medical reasons.

Table 5. Binomial logistic regression predicting OSUE.

	OR	95% CI FOR OR		*P* VALUE
		LOWER	UPPER	
Gender				
Male				
Female	0.60	0.39	0.91	.016
Smoking status				
Never				
Former	1.87	1.16	3.04	.021
Current	1.24	0.66	2.32	.733
Reason for using e-cigarettes				
Use under ban				
No				
Yes	1.29	0.82	2.02	.268
Trendy or cool				
No				
Yes	2.89	1.53	5.45	.001

Abbreviations: CI, confidence interval; OR, odds ratio; OSUE, other substance use in e-cigarettes.

Finding that OSUE is associated with men is consistent with research regarding drug use in general[26] and also with several recent studies examining OSUE.[6,8,9,11] In contrast to studies regarding general drug use, this study did not find younger age or white ethnicity to be associated with OSUE. Although drug use in general is typically associated with younger age, the association between age and e-cigarette use to vaporize other substances has been mixed. Finding that Greek affiliation was not associated with OSUE was unexpected, given that most studies consistently find risky behaviors such as alcohol and drug use to be greater among Greek-affiliated college students.[27] That said, this study included a relatively low number of participants reporting Greek affiliation, which may have affected findings. The finding that current smokers were significantly more likely to report OSUE than nonsmokers is not surprising in light of the fact that most respondents reported cannabis or a cannabis derivative as the substance used in an e-cigarette, and research has shown that nearly 90% of cannabis users are also cigarette smokers.[28] The current findings also align with similar research by Sutfin et al[4] regarding other substance use in hookah or water pipes by college students.

Electronic cigarette users reporting OSUE generally reported past 30-day use of other drugs at significantly higher rates than those not reporting OSUE. Several studies have shown that cannabis use is associated with other illicit drug use, and given that most reported OSUE in this study was with cannabis, this association is not surprising.[29–31] Other studies of e-cigarette use have found that illicit drug use is associated with cannabis vaping.[11] Perhaps more interesting is the finding that respondents reporting OSUE showed rates of ecstasy and hallucinogen use and prescription pain medication misuse that were 52.2% to 61.5% higher than respondents not reporting OSUE. However, because this study is the first to compare rates of illicit drug use across different drug types between e-cigarette users reporting OSUE and those not reporting OSUE, direct comparisons with similar works are not possible. Although many hypotheses could be proffered to explain the high rates of past 30-day use of ecstasy, hallucinogens, and prescription pain medication found in this study, a simple explanation is that polysubstance use is likely already present in the OSUE subset, and e-cigarettes offer users a novel, and perhaps, more efficient means by which to ingest the substances.

Finding that among this population OSUE is overwhelmingly cannabis or cannabis derivatives comes as no surprise, given the popularity of cannabis use, especially among college populations and the increased acceptability of use and decreased perceptions of harm of cannabis among this population.[32,33] Although this study found relatively low rates of substances other than cannabis being vaped using e-cigarettes, given the apparent interest via YouTube videos and online forums devoted to drug-using groups in vaping substances that most would consider more dangerous than cannabis (eg, methamphetamine, prescription opioid drugs) and increasingly more potent forms of cannabis, this emerging trend of OSUE should be closely monitored.

The 3 most common reasons for e-cigarette use were the same for both OSUE and non-OSUE groups. However, the ranking of the top 3 reasons for each group differed, with the OSUE group reporting "safer than cigarettes" as the primary reason for e-cigarette use and the non-OSUE group reporting "experimentation" as the primary reason for e-cigarette use. Although limited, other studies assessing reasons for e-cigarette use have found similar reasons. Among college students reporting the use of e-cigarettes to vape cannabis, Jones et al[11] found that most of the respondents used e-cigarettes primarily because they were more convenient and more discreet for use in public and secondarily because they considered e-cigarettes to be healthier than smoking. In a study by Bold et al,[34] middle and high school students reported using e-cigarettes primarily out of curiosity but also for "good flavors," because friends use, and because e-cigarettes are healthier than cigarettes. Variation in findings is due in part to how the question was asked in each study (eg, select all that apply vs select the primary reason for use). Our finding that e-cigarette users who report OSUE also report "experimentation" as the primary reason for e-cigarette use may lend support to the idea discussed above that other substance use may already be present in this population and the introduction of e-cigarettes has provided this population with a novel way to ingest many of those drugs.

Of interest is the finding that students using e-cigarettes for "trendy or cool" reasons were associated with a nearly 3-fold increase in the odds of OSUE. Multiple factors are likely to be responsible for this finding, many of which are beyond the scope of this study. However, one possible explanation is an interplay among e-cigarette marketing, product availability, and the inclination to try new technologies and substances. For example, e-cigarette marketing tends to target youth and young adults[35] and thus attracts young adults to the product. Availability of e-cigarettes,[36] cannabis and cannabis derivatives,[21] and accessories specifically designed for OSUE has increased in recent years. In combination, these factors may promote and encourage OSUE in this young college population.

This study is not without limitations and thus findings should be interpreted within the context of its limitations. The present research reports on data collected in 2014. Hence, the current findings may underestimate the incidence of OSUE in the population, given the growing interest in e-cigarettes over recent years.[2] Additional research is needed to establish trends over time in OSUE among college populations. The generalizability of the present findings is limited because data were collected from one specific Midwestern university. Future research should replicate and expand this work at other universities. Furthermore, because incidence or frequency of OSUE was not collected, it is not possible to know whether OSUE use was primarily a single episode or

repeated behavior among respondents. Future research should include the measurement of frequency of OSUE, given that these 2 groups of OSUE users may differ substantially. Although suitable for estimating prevalence, the cross-sectional design of the study cannot show causation and is susceptible to nonresponse bias. The relatively low survey response rate further increases the potential for nonresponse bias to affect study findings. That said, there is an increasing body of research that indicates that low response rates do not necessarily equate to biased results.[37,38] Several strategies were implemented to reduce nonresponse, including incentivizing participation using a lottery with a relatively high probability of winning a prize[39] and sending email reminders to those who had not initiated or completed the survey. Although self-reported drug abuse data are generally found to be valid and reliable,[40,41] this study relied on self-report and thus underestimates of use or incorrect recall of information may have influenced findings, especially regarding internal validity.

Despite its limitations, this study is one of a very few that provide insight regarding the use of other substances in e-cigarettes among college students. Although a relatively low prevalence rate of OSUE was found, as the popularity of e-cigarettes continues to grow, so could a real public health concern. This concern may have the potential to substantially affect college health, given that we know very little about the effects of cannabis and cannabis derivatives (typically comprising higher THC concentrations than traditional forms of cannabis) delivered through e-cigarettes. In addition, concern may be warranted regarding the potential dangers of using substances more dangerous than cannabis. For instance, although this study identified only a very small number of individuals reporting the use of what many would consider more dangerous illicit substances (eg, cocaine), there is the potential for an increase in the prevalence of OSUE and thus the potential for larger numbers of individuals vaping more dangerous drugs. Future research examining reasons for OSUE, drug use history, and e-cigarette and drug use trajectories of individuals who use other substances in e-cigarettes using longitudinal designs will be needed.

This study is among one of a small but growing number of studies reporting on the use of other substances in e-cigarettes. This study provides valuable insight into the growing prevalence of e-cigarette use and OSUE among college students, their potential contribution to the use of harmful illicit substances, and differing primary reasons for misuse across e-cigarette users. This study adds to the extant literature specific to the college student population, of which there is very little information regarding OSUE, and findings stress the need for continued research emphasis on the combination of vaping and illicit substance use among college students, as limited knowledge exists on the impact of these behaviors, motivations behind it, and its potential public health impact.

Author Contributions

DK, RF, AT and MB conceived the research. DK and MB wrote the first draft of the manuscript. RF conducted the data analysis. AT contributed to the writing of the manuscript and data analysis. All authors reviewed and approved the final manuscript.

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